(1)

PATENT ABSTRACTS OF JAPAN

(11)Publication number : **11-000776**
(43)Date of publication of application : **06.01.1999**

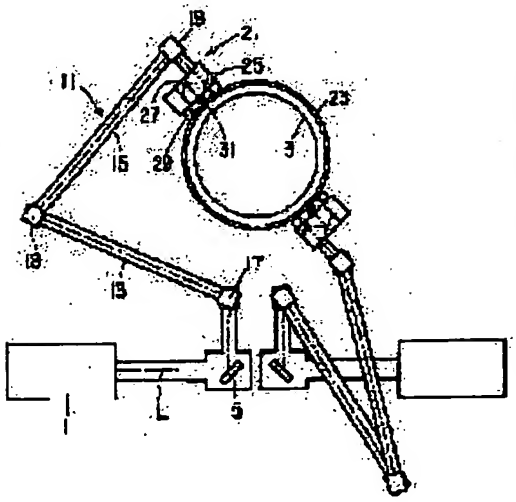
(51)Int.CI. B23K 26/00
B21C 37/08
B23K 26/08
C22C 38/00
C22C 38/04

(21)Application number : **10-093218**
(22)Date of filing : **06.04.1998**

(71)Applicant : **NIPPON STEEL CORP**
(72)Inventor : **MINAMIDA KATSUHIRO**
OIKAWA MASASHI
KOGA ICHIRO
KAWAI YASUHIRO

(30)Priority
Priority number : **09 88501** Priority date : **07.04.1997** Priority country : **JP**

(54) OSCILLATING LASER WELDING METHOD FOR STEEL TUBE



(57)Abstract:
PROBLEM TO BE SOLVED: To enable a high quality weld joint to be obtained that is free from weld metal solidification crack or weld zone hardening by welding by moving a laser irradiation position at a specific speed while it is oscillated with a specific amplitude and frequency against the abutting line.
SOLUTION: A laser beam L from a laser generator 1 is transmitted to a working head 21 through a beam duct 13, 15. With the laser beam emitted from the working head 21, the abutting part of a steel tube 3 is melted and welded. The steel tube is welded by moving a laser irradiation position along the abutting part of the tube at 0.5-3.0 m/sec while the position is oscillated with an amplitude of 0.5-1.0 mm and a frequency of 10-60 Hz in the abutting line direction and/or in the direction vertical to it. The steel tube is constituted, in weight %, of 0.01-0.31% C, 0.5% or less Si, 1.0-2.0% Mn, 0.03% or less P, 0.03% or less S, and the remainder Fe and inevitable impurities.

CLAIMS

[Claim(s)]
[Claim 1] In the laser-welding method of the steel pipe which compares a steel pipe and welds by irradiating laser and making the matching section fuse it The matching section of a steel pipe is met in a laser radiation location, vibrating a laser radiation location perpendicularly to the matching line of a steel pipe with the amplitude of 0.5-1.0mm, and the vibration frequency of 10-60Hz, and it is 0.5-3.0m/sec. The oscillating laser-welding method of the steel pipe characterized by making it move and welding a steel pipe.
[Claim 2] In the laser-welding method of the steel pipe which compares a steel pipe and welds by irradiating laser and making the matching section fuse it The matching section of a steel pipe is met in a laser radiation location, vibrating a laser radiation location to the matching line direction of a steel pipe with the amplitude of 0.5-1.0mm, and the vibration frequency of 10-60Hz, and it is 0.5-3.0m/sec. The oscillating laser-welding method of the steel pipe characterized by making it move and welding a steel pipe.
[Claim 3] In the laser-welding method of the steel pipe which compares a steel pipe and welds by irradiating laser and making the matching section fuse it [vibrating the matching line direction of a steel pipe with the amplitude of 0.5-1.0mm, and the vibration frequency of 10-60Hz, while vibrating a laser radiation location to the matching line and perpendicular direction of a steel pipe with the amplitude of 0.5-1.0mm, and the vibration frequency of 10-60Hz] The matching section of a steel pipe is met in a laser radiation location, and it is 0.5-3.0m/sec. The oscillating laser-welding method of the steel pipe characterized by making it move and welding a steel pipe.
[Claim 4] The oscillating laser-welding method of a steel pipe according to claim 1, 2, or 3 that said steel pipe contains less than Si:0.5%, Mn:1.0-2.0%, P:0.03% or less, and S:0.03% or less C:0.01 to 0.31% by weight %, and the remainder consists of Fe and an unescapable impurity.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the laser-welding method of a steel pipe.
[0002]
[Description of the Prior Art] Since a laser-welding method has the description which has a high penetration ratio, and little processing distortion that high speed welding is possible and few remains heat affected zones are, future development is the field expected very much. About applying this laser-welding method to butt welding of a steel pipe and a steel pipe, it has been proposed from the former.
[0003] The method of irradiating high energy beams, such as a laser beam, on the surface of a pipe, and specifically welding a steel pipe, for example to JP,S56-36395,A is indicated. Moreover, the processing equipment of the pipe which used laser is indicated to JP,S58-148089,A.
[0004]
[Problem(s) to be Solved by the Invention] However, there were the following problems in butt welding of a steel pipe by the conventional laser welding.
1) Since cutting of a steel pipe is usually performed by a gas-cutting method etc., as for the configuration of a cut section separating from a straight line according to the description of a steel pipe, the imperfect alignment of a steel pipe and a guide rail, etc., ** does not have ****. For this reason, a gap arises in the matching section of a steel pipe and a steel pipe. If this gap

is larger than the width of the fusion zone of laser welding, a steel pipe will not be welded in that part.
2) The configuration of the fusion zone formed in the matching section of a steel pipe may have the large difference of the maximum width of a fusion zone, and minimum width, as shown in drawing 1 , and for this reason, a coagulation crack may occur in a fusion zone. For example, C:0.31% or less, Mn : 3) 2.0% or less, P:0.08% or less, By small laser welding of a fusion zone, when applying a high-speed laser-welding process to steel which contains S:0.06% or less, since cooling of a fusion zone is performed comparatively at high speed, a weld zone higher-hardness-izes and the property of a steel pipe becomes an ununiformity. On the other hand, if fusion width is enlarged by powerful-ization of the lowering and laser power of the speed of travel etc., it is possible to make cooling of a fusion zone late, but it melts into a fusion zone in this case, and becomes easy to generate omission. Since a position of weld serves as ****** and facing up especially in the case of a steel pipe, it is easy to produce lappet omission.
4) It is shut up in the fusion zone which the air bubbles generated in the fusion zone solidified, becomes a blowhole, and becomes the cause of a coagulation crack. It aims at offering the laser-welding method of a steel pipe that this invention solves the trouble of the conventional technology mentioned above, and the outstanding welded-joint section is obtained.
[0005]
[Means for Solving the Problem] This invention is as follows.
(1) In the laser-welding method of the steel pipe which compares a steel pipe and welds by irradiating laser and making the matching section fuse it The matching section of a steel pipe is met in a laser radiation location, vibrating a laser radiation location perpendicularly to the matching line of a steel pipe with the amplitude of 0.5-1.0mm, and the vibration frequency of 10-60Hz, and it is 0.5-3.0m/sec. The oscillating laser-welding method of the steel pipe characterized by making it move and welding a steel pipe.
(2) In the laser-welding method of the steel pipe which compares a steel pipe and welds by irradiating laser and making the matching section fuse it The matching section of a steel pipe is met in a laser radiation location, vibrating a laser radiation location to the matching line direction of a steel pipe with the amplitude of 0.5-1.0mm, and the vibration frequency of 10-60Hz, and it is 0.5-3.0m/sec. The oscillating laser-welding method of the steel pipe characterized by making it move and welding a steel pipe.
(3) In the laser-welding method of the steel pipe which compares a steel pipe and welds by irradiating laser and making the matching section fuse it [vibrating the matching line direction of a steel pipe with the amplitude of 0.5-1.0mm, and the vibration frequency of 10-60Hz, while vibrating a laser radiation location to the matching line and perpendicular direction of a steel pipe with the amplitude of 0.5-1.0mm, and the vibration frequency of 10-60Hz] The matching section of a steel pipe is met in a laser radiation location, and it is 0.5-3.0m/sec. The oscillating laser-welding method of the steel pipe characterized by making it move and welding a steel pipe.
[0006] The oscillating laser-welding method of this invention contains less than Si:0.5%, Mn:1.0-2.0%, P:0.03% or less, and S:0.03% or less C:0.01 to 0.31% by weight %, and can apply it to the steel pipe with which the remainder consists of Fe and an unescapable impurity. C is an essential ingredient to the toughness of a steel pipe, and reservation of tensile strength. Mn is an essential ingredient to reservation of toughness tensile strength and an impact resistance value similarly. Moreover, it is also applicable to the steel pipe which fulfills API5L specification. You may add at least one of the alloying elements, such as Cu, nickel, Mo, Nb, V, Ti, and B, if needed.
[0007] The configuration of the weld zone formed in drawing 1 (a) by the conventional laser-welding method is shown. As shown in this drawing, with the conventional laser-welding method, it is the maximum fusion width WMAX. The minimum fusion width WMIN The

difference was large and the frequency which a coagulation crack as shown in drawing 1 (b) after coagulation generates was also high.
[0008] Correlation with the value of {(WMAX-WMIN) /average fusion width} and coagulation crack die length is shown in drawing 2 . The ratio (%) to the whole thickness of the weld zone of the die length of the coagulation crack generated as an index of coagulation crack die length in drawing 2 is used. Moreover, data are 12kWCO2 to the matching section of 15mm steel plates. It is laser Power density 1.5 MW/cm2 It irradiates and is speed-of-travel 1.0 m/min. It is a thing at the time of carrying out laser welding. If the value of {(WMAX-WMIN) /average fusion width} is made small as shown in drawing 2 , it turns out that generating of a coagulation crack can be reduced.
[0009] So, [this invention / vibrating a laser radiation location perpendicularly (henceforth the direction of Y) to the matching line of a steel pipe with the amplitude of 0.5-1.0mm, and the vibration frequency of 10-60Hz] The matching section of a steel pipe is met in a laser radiation location, and it is 0.5-3.0m/sec. We decided to make it move and to weld a steel pipe. The configuration of the weld zone obtained by performing laser welding to drawing 3 , vibrating a laser radiation location in the direction of Y in the range of this invention is shown. In the weld zone by this invention, the value of {(WMAX-WMIN) /average fusion width} is close to 0, and can reduce generating of a coagulation crack. Moreover, since the fusion width by this invention is wider than the fusion width by a conventional method, it is effective also in prevention and reduction of an eye blank.
[0010] Here, the matching section of a steel pipe is met in a laser radiation location, and it is 0.5-3.0m/sec. Make move, namely, it is 0.5-3.0m/sec about the speed of travel. [having carried out] It is for the input calorie to a steel pipe to become excessive in less than 0.5m/sec, to melt, and for omission etc. to occur, and is 3.0m/sec. In **, conversely, and it is for welding incompetence to occur. [the input calorie to a steel pipe]
[0011] Moreover, the conditions at the time of vibrating a laser radiation location in the direction of Y are described below about the Reason specified as mentioned above. It aims at expanding the width of the fusion zone formed in the steel pipe matching section, and the value of {(WMAX-WMIN) /average fusion width} obtaining the fusion zone of the uniform width near 0 by vibrating a laser radiation location in the direction of Y, in this invention. Here, if the oscillation of the direction of Y is less than 10Hz, it is only that a fusion zone only moves in a zigzag direction, and the object of this invention cannot be attained. Moreover, even if it makes the oscillation of the direction of Y quick exceeding 60Hz, effectiveness approaches saturation, and the burden by the side of equipment only becomes large. So, in this invention, the oscillation of the direction of Y was 10-60Hz. Moreover, at less than 0.5mm, the effectiveness of this invention is not fully acquired for the amplitude of the direction of Y, but it is possible that more than 1.0mm, then a fusion zone separate from a matching line. So, in this invention, the amplitude of the direction of Y was 0.5-1.0mm.
[0012] Moreover, you may perform laser welding with the speed of travel mentioned above while vibrating the laser radiation location with the amplitude of 0.5-1.0mm, and the vibration frequency of 10-60Hz to the matching line direction (it is hereafter considered as the direction of X) of the steel pipe.
[0013] Thus, the heat history of the weld zone at the time of performing laser welding is roughly shown in drawing 4 , vibrating a laser radiation location in the direction of X. The heat history of the weld zone in a conventional method is collectively shown in drawing 4 . The time amount taken to cool the weld zone by this invention method from 800 degrees C to 500 degrees C is longer than the same duration in a conventional method as indicated to drawing 4 . Therefore, the cooling rate of the weld zone by this invention is looser than a conventional method, and serves as the heat history to which hardening of a weld zone cannot get up easily.
[0014] By this invention method, as shown in drawing 4 , since the time amount in which

molten metal stagnates more than the melting point is long, the air bubbles generated in molten metal surface, become easy to slip out of the inside of molten metal from a fusion zone, and are effective in generating of a blowhole being reduced.

[0015] The conditions at the time of vibrating a laser radiation location in the direction of X are described below about the Reason specified as mentioned above. It aims at preventing hardening of a fusion zone and reducing blowhole generating by vibrating a laser radiation location in the direction of X, and controlling the heat history of a weld zone by this invention. The effectiveness that the amplitude of a laser radiation location makes it vibrate in less than 0.5mm does not show up here, but control of the heat history is inadequate. On the other hand, even if it vibrates a laser radiation location with the amplitude of more than 1.0mm, it hangs down to molten metal according to buildup of fusion width, and omission occurs, and it becomes a weld flaw. Then, the amplitude of the laser radiation location was 0.5-1.0mm.

[0016] Moreover, if the vibration frequency of the laser radiation location was less than 10Hz in the speed-of-travel range of this invention, and the direction amplitude range of X, the velocity of vibration is too slow and the effectiveness of this invention is not acquired. It becomes [the burden by the side of about / that effectiveness approaches saturation also as more than 60Hz / and equipment] large on the other hand and is not desirable. Then, the vibration frequency of the laser radiation location was 10-60Hz.

[0017] Furthermore, you may be made to perform laser welding, making it vibrate also in the direction of X at the same time it vibrates a laser radiation location in the direction of Y. The frequency condition for all directions at this time is equivalent to the conditions at the time of making it vibrate according to an individual respectively, and good.

[0018]

[Embodiment of the Invention] The form of operation of this invention is explained below. An example of equipment which enforces the oscillating laser-welding method of the steel pipe of this invention to drawing 5 is shown roughly. As for the steel pipe and L whose 3 is a workpiece, as for a laser beam and 1, in drawing 5 , laser transmission equipment and 21 are processing heads a laser oscillator and 11. As a laser oscillator 1, it is with an output of 10-30kW continuous wave CO2, for example. The laser oscillator is suitable. It is reflected by the mirror 5 and the laser beam L which acted as Idei from the laser oscillator 1 is introduced into the laser transmission equipment 11.

[0019] The laser transmission equipment 11 consists of the 1st splice 17, the 1st beam duct 13, the 2nd splice 18, the 2nd beam duct 15, and the 3rd splice 19. Each beam duct is a hollow cylinder-like, and a laser beam is transmitted in the interior. The structure of the 2nd splice 18 is roughly shown in drawing 6 . The 1st beam duct 13 and the 2nd beam duct 15 are mutually connected free [rotation] through the bearing 35. A laser beam L is transmitted into the 2nd beam duct 15 from the inside of the 1st beam duct 13 by the mirror 31 arranged in the 1st beam duct 13, and the mirror 33 arranged in the 2nd beam duct 15. Although the 2nd splice 18 was explained above, it has the structure and function as this also with same 1st splice 17 and 3rd splice 19. According to the above structures, bending by each splice is free for the laser transmission equipment 11, and it can transmit a laser beam L to the beam duct of the downstream from the beam duct of the upstream.

[0020] By the above laser transmission equipment 11, a laser beam L is transmitted to the processing head 21. On the processing head 21, the mirror 25 and the condensing optical system 27 are arranged, and a laser beam L is irradiated by the welded part 31 of a steel pipe 3 by these.

[0021] What is necessary is to combine a mirror 25 and the condensing optical system 27, as shown, for example in drawing 7 and drawing 8 , and just to vibrate a mirror 25 to an arrow direction, in order to vibrate a laser radiation location according to this invention method. In drawing 7 and 8, the direction of welding can vibrate level, then a laser radiation location in

the direction of X to space, and the direction of welding can vibrate vertical, then a laser radiation location in the direction of Y to space. In addition, although the mirror 25 is vibrated in drawing 7 and 8, even if it vibrates the condensing optical system 27, it cannot be overemphasized that the same effectiveness is acquired.

[0022] If it is made to go around here on the guide rail 23 in which the processing head 21 was formed by the periphery of the steel pipe 3 with the processing head drive 29, it is possible to weld over the steel pipe matching section perimeter.

[0023]

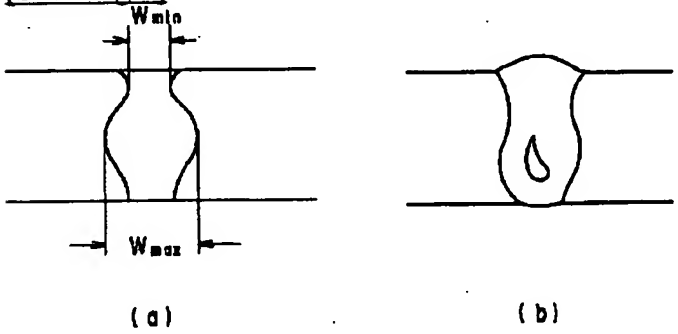
[Example] About 711mm in diameter and the steel pipe for pipelines of about 15mm of board thickness were welded using the above-mentioned equipment. In the laser oscillator 1, it is CO2 [with an output of 25kW]. About a laser oscillator, they are 150mm of appearances in a beam duct, The ball bearing with an outer diameter of 150mm specified as the bearing by JIS in the stainless steel pipe with a bore of 144mm and a thickness of 3mm was used, respectively. The laser beam was made to be condensed with the diameter of 0.5mm on the steel pipe matching section surface by the condensing optical system using the parabolic mirror with a focal distance of 500mm.

[0024] [here / the location where a laser beam is irradiated by the steel pipe matching section surface / vibrating a mirror 25 so that it may vibrate in amplitude:0.7mm, vibration frequency:50Hz, and the direction of oscillating direction:Y] It is the processing head 21 Rate 1.0 m/min When it was made to go around, the eye blank of laser was able to obtain the quality welded joint as which it does not generate and hardening of the coagulation crack of a weld zone or a weld zone is not regarded, either.

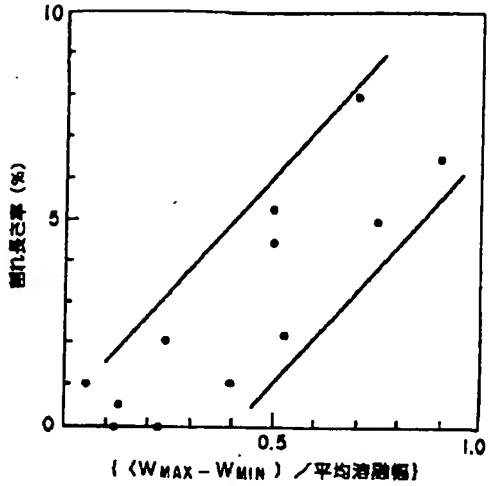
[0025] Moreover, when it welded by vibrating a mirror by the same welding condition so that a laser radiation location might vibrate in amplitude:0.7mm, vibration frequency:50Hz, and the direction of oscillating direction:X, similarly the welded joint of high quality was able to be obtained.

DRAWINGS

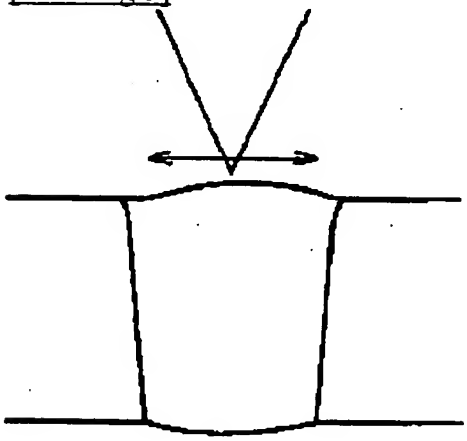
[Drawing 1]



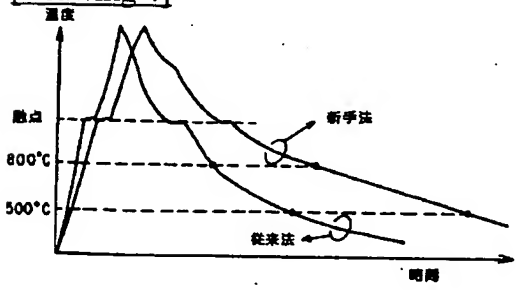
[Drawing 2]



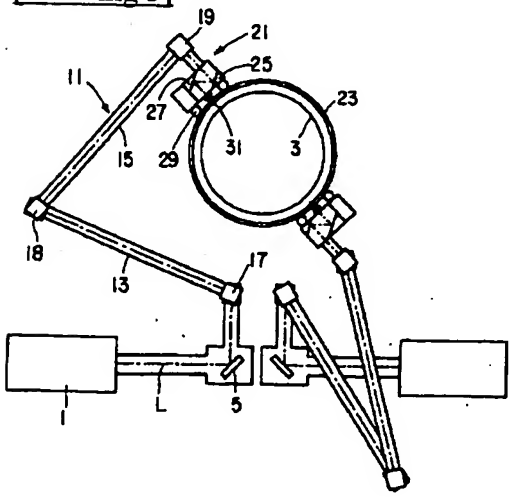
[Drawing 3]



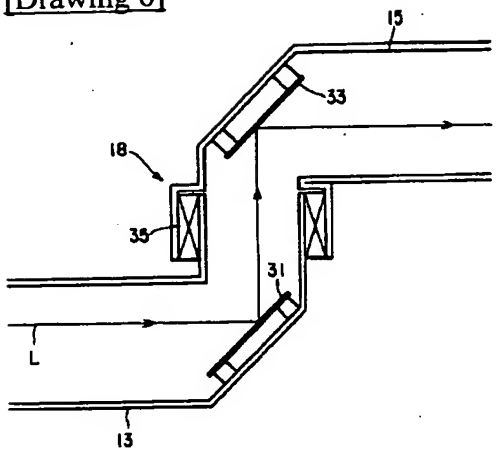
[Drawing 4]



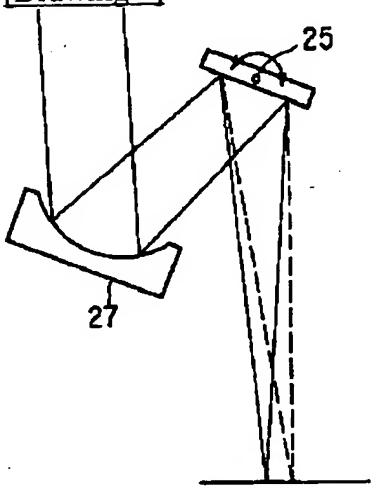
[Drawing 5]



[Drawing 6]



[Drawing 7]



[Drawing 8]